Donald P. Brutzman

Curriculum Vitae

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I. BIOGRAPHICAL INFORMATION

1. Demographic Information

a. Donald Paul Brutzman
b. Assistant Professor
c. Root Hall, room 200
d. Telephone 831.656.2149 office, 831.656.3679 fax
e. US citizenship
f. Currently hold SECRET clearance and access.

2. Career Goal

a. Design and implement a large-scale networked underwater virtual world, using Web-accessible 3D graphics and network streams. Integrate sensors, models and datasets for real-time interactive use by scientists, underwater robots, ships and students of all ages.

3. Education

a. 1994: Ph.D. in Computer Science with minor in Operations Research, Naval Postgraduate School, Monterey California. Dissertation title: "A Virtual World for an Autonomous Underwater Vehicle." Dissertation advisor: Michael J. Zyda. Fields of concentration: 3D graphics, networking, robotics and artificial intelligence. Period of study 1992-1994.

b. 1992: Master of Science in Computer Science, Naval Postgraduate School, Monterey California. Thesis title: "Integrated Simulator for an Autonomous Underwater Vehicle." Thesis advisors: Michael J. Zyda and Yutaka Kanayama. Received Superintendent's Superior Service award. Fields of concentration: 3D graphics, networking, robotics and artificial intelligence. Completed departmental requirements for artificial intelligence and graphics specialization tracks. Period of study 1990-1992.

c. 1983: Qualified as Nuclear Engineer aboard nuclear-powered submarines, Naval Reactors Bureau, U.S. Navy, Washington D.C.

d. 1978: B.S.E.E. in Electrical Engineering, U.S. Naval Academy, Annapolis Maryland. Full scholarship commencing in 1974 with Congressional sponsorship, alternate selectee for Vice Presidential sponsorship.

4. Chronology of professional history

a. 1999-present: joint affiliation with NPS Modeling, Virtual Environments and Simulation (MOVES) Academic Group.

b. 1995-present: Assistant Professor in Applied Science, tenure track, Undersea Warfare Academic Group, Naval Postgraduate School, Monterey California.

c. 1992-1994: Military Instructor in Operations Research Department, Naval Postgraduate School. Upon completion of tour of duty, retired from active service in U.S. Navy as Lieutenant Commander.

d. 1990-1992: Masters student, Computer Science Department, Naval Postgraduate School.

e. 1988-1990: Navigator and Combat Systems Officer, USS BREMERTON SSN 698, Pearl Harbor Hawaii. Included operational tour and overhaul.

f. 1988: Submarine Officer Advance Course (SOAC), Groton Connecticut.

g. 1986-1988: Combat Systems Officer & commissioning crew plankowner, USS HONOLULU SSN 718, Pearl Harbor Hawaii.

h. 1983-1986: Operational Test Director, Operational Test and Evaluation Force, Norfolk Virginia. Authored final evaluation report for CCS MK 1 Combat Control System and performed initial developmental at-sea evaluations for Mk 48 Advanced Capability (ADCAP) Torpedo at Andros Island, Bahamas.

i. 1979-1983: Electrical Officer, Communicator and Damage Control Assistant, USS GEORGE C. MARSHALL SSBN 654), Groton Connecticut and Holy Loch, Scotland. Included operational tour and overhaul.

j. 1978-1979: Student, Nuclear Power School in Orlando Florida and Nuclear Power Prototype Training (S1C plant) in Windsor Connecticut.

k. 1974-1978: Midshipman, United States Naval Academy, Annapolis Maryland.

5. Academic concentrations and research interests

My primary discipline is Computer Science, with focused efforts in four subfields. Underwater robotics and virtual environments are both fields that require a tremendous amount of cross-disciplinary endeavor. My research interests have always been very broad as a consequence of my naval training and responsibilities. I have ongoing collaborations with mechanical engineers, electrical engineers, acousticians, oceanographers, educators and other researchers outside of computer science. My research endeavors are cross-cutting and synthesize original work in the following subfields.

a. Computer Graphics: 3D real-time virtual worlds and sonar visualization

b. Robotics: building operational Autonomous Underwater Vehicles (AUVs)

c. Artificial Intelligence: machine learning, sensing and perception, control

d. High-Performance Networking: distributed audio/video/graphics applications using multicast, Distributed Interactive Simulation (DIS), and adaptive protocols for large-scale virtual environments (LSVEs)

6. Professional certifications or registrations.

a. Patent applied for. Whitfield, Martin and Brutzman, Donald P., *Low-Cost Digital Signal Processor (DSP)-Based Torpedo Countermeasure (U)*, Naval Postgraduate School, Monterey California, June 1997. Invention disclosure has been approved for patenting by NPS. Patent preparation is in progress and filing is expected with U.S. Patent and Trademark Office during calendar year 2000.

II. INTERNAL NPS ACTIVITIES

1. Internal Teaching Activities

a. Course and laboratory development. Description of courses developed, instructional materials written, laboratory facilities acquired, and experiments developed. Indicate any development work that supported operational curricula.

i. OA2200 COMPUTATIONAL METHODS FOR OPERATIONS RESEARCH (4-1). I transitioned this beginning programming course for OR students from Fortran to Pascal. Developed completely new curriculum and lab support. Instructional materials provided to follow-on instructor, increased scope of student programming capabilities laid the foundation for later transition to a Java-based curriculum. This work performed while serving as a military instructor in the Operations Research Department.

ii. OA3302 OA SYSTEM SIMULATION (4-0). I added new project sections and taught Dr. Mike Bailey's discrete-event simulation (DES) course for OR students.

iii. UW3303 MODELING AND SIMULATION FOR UNDERSEA WARFARE (4-1). I created a new course providing a survey of simulation techniques with grading based on programming projects. This course is successfully transitioning from C/C++ to the MatLab programming language, since UW students are no longer afforded any prerequisite programming course. From the course description:

> Design, implementation and analysis using digital simulation models, with emphasis on physics-based modeling of military systems. Simulation is a discipline that cuts across all technical fields complementing both theory and experiment as a component of the scientific method. Course topics include a broad view of analytic simulation, properly designing and structuring simulation problems, extending student programming skills to include the C language (as necessary), use of on-line tutorials, and use of public domain C++ compiler/simulation toolkit (g++, simpack). UW3303 provides tools, techniques and a repeatable methodology that can be used to support thesis work and projects in other classes. Examples and class projects are typically oriented to problems of military or scientific interest.

iv. MV4204 COMPUTER GRAPHICS USING VRML (3-2). I developed MV4204 to teach new students how to author 3D graphics for the Web. This course receives strong and increasingly enthusiastic support from computer-graphics

students as well as students in a variety of other NPS curricula. It is an allowed alternative for MV4202, INTRODUCTION TO 3D GRAPHICS. Further innovations continue. Through my efforts with the Extensible 3D (X3D) Graphics specification, I have developed the software for a new authoring tool (X3D-Edit) that has significantly enhanced student productivity. This work directly builds on prior VRML efforts since X3D is an alternate encoding of VRML using the Extensible Markup Language (XML). The same textbook continues to be used, now with corresponding X3D examples available to supplement the original VRML examples. Course page is available online at http://web.nps.navy.mil/~brutzman/vrml. From the course description:

An introduction to the principles of hardware and software used for computer-generated 3D graphics via the World Wide Web. The focus of the course is authoring interactive 3D scenes and a major design project. The course is intended for MOVES and Computer Science students working in visual simulation, or students in other majors interested in the basics of 3D modeling and rendering.

v. MV4205 ADVANCED MODELING USING VRML/X3D (3-2). This course is being taught right now as a MV4920 directed study, but is ready for Academic Council consideration as regular course MV4205. Students learn advanced modeling and rendering techniques using X3D-Edit by building individual projects that are merged into an integrated Web-based 3D world. Our current challenge includes authoring models of Russian, American and international ships and aircraft, and then integrating them into a operator-controllable tactical scenario. I thereby expect to build a credible periscope training system for use by students and submarine crews at the Naval Submarine School in Groton Connecticut, replacing archaic 3D equipment delivered in 1979. This effort also demonstrates how I focus student course efforts in directions that support external research and also link NPS products to fleet needs.

vi. CS/MV4920 ADVANCED TOPICS IN COMPUTER SCIENCE / MODELING, VIRTUAL ENVIRONMENTS AND SIMULATION. I frequently offer directed studies, on average one per quarter for 2-5 students. Typically such directed-study course offerings do not reimburse any teaching salary. These have been used for trial versions of new courses and to support directed study in topics needed for thesis work. Topics have included four classes for recording and digitizing the Hamming lecture series, sonar visualization, tactical robot software modules, underwater data communications, network control of humanoid avatars, radio-signal scientific visualization, etc.

b. DoN/DoD applications. Describe any contributions made in instructional-related activities, emphasizing DoN/DoD applications.

i. Electronic classroom. During 1995-1997 I experimented with creation of an electronic classroom in Root 200C that included PC, PC projector, video projector, video camera and audio microphones. Lessons learned included importance of multiple screens, wireless miking and fine-grain lighting control. A number of class sessions included participation by regional partners via Internet MBone. This prototype classroom led to better engineering and equipment in Root 200C and Root 228. Some lessons learned were incorporated in the video-teleconferencing (VTC) room design, but not all: there is still no support provided for the freeware MBone audio/video tools, reportedly because of insufficient funding for a PC.

ii. MV4204 distance learning. In September 2000 I was on temporary duty to the Naval Coastal Systems Center (NCSC) in Panama City participating with our AUV group in Fleet Battle Experiment Hotel (FBE-H). I gave one week of MV4204 class back to the NPS distance-learning VTC classrooms via PictureTel link. This was successful, as judged by the students. Several problems were detected and reported to NPS staff, including unsatisfactory ambient noise feedback when unmuted and a lack of remote camera control. These problems are being addressed. Based on requests, I expect to offer MV4204 via VTC to NCSC and to the Naval Undersea Warfare Center (NUWC) in Newport Rhode Island in future quarters.

iii. See MV4205 for application of 3D model building towards an integrated tactical team trainer.

iv. Discuss UW3303 search plan development, development of robot software, and use in virtual world visualization projects.

v. Distributed Interactive Simulation (DIS) Overview Course. Sponsored by the Operations Research Society of America (ORSA) Continuing Education Program and Army Logistics Management College, Fort Belvoir Virginia, February 1996. Prepared and presented a one-week short course on use of the IEEE Distributed Interactive Simulation (DIS) protocol in military simulation systems.

c. Teaching techniques developed. List any techniques developed; include information on planning, testing, and evaluation.

i. Hamming lecture series. The late Richard W. Hamming made numerous fundamental contributions to mathematics and computer science. He passed away suddenly on January 7, 1998. For many years he taught a capstone course on the future of science and engineering at the Naval Postgraduate School (NPS). In 1995 two of my students and I recorded and broadcast this course live across the nascent Internet Multicast Backbone (MBone) for a full quarter. This was the first full-length academic course presented in such a manner. Peak remote attendance was 41 people. In 1998 four students succeeded in digitizing all 30 recorded lectures for on-demand playback using Wieland Hofhelder's MBone VCR On Demand (MVoD) software. The online course was available for six months, but the server software did not survive various hardware and operating system upgrades. Playability was further compromised by the completely inconsistent software configurations installed on the various computers available to faculty and students on campus. This work has been fully documented in a series of theses listed below. My goal for the coming year is to repeat this video digitization using more robust software for permanent archival and retrieval, once again offering this unique course for credit to NPS students and viewers worldwide. A successful weekly presentation format for credit is for students to view three lectures individually, and then meet for an hour of group discussion. Project details are updated online at http://web.nps.navy.mil/~brutzman/hamming

Further descriptions and evaluations of use of MBone for distance learning appear in theses II.1.d.xi, xvi-xxii, xxvii, xlv and xlviii, as well as publications III.2.a.xi, xxvii and xxviii.

Reference: Hamming, Richard W., *The Art of Doing SCIENCE and Engineering: Learning to Learn*, Gordon and Breach Science Publishers, Amsterdam B.V, The Netherlands, 1997. This final work provides complete documentation of his capstone lecture presentations. Richard Hamming remains foremost among numerous strong individuals who have influenced my thinking. His meticulous dedication to the scientific method, clarity and education remain worthy exemplars for NPS students.

ii. Project-based grading. Advanced computer science, modeling, simulation and programming are all "hands on" topics. I no longer give written tests in such courses. Instead, students complete a series of small-example assignments and then produce a large impressive project for public demonstration. Students need to apply pertinent theoretical knowledge in demonstrated practical capabilities. My advertised criterion for grading students is that each demonstration must pass the "quantitatively cool" test, i.e. peers and evaluators knowledgeable in the subject area must consider the demonstration results both thought provoking and

impressive. In other words, viewers apply the gold-standard metric of graphics-community terminology: "cool." Interestingly, individual and group projects frequently attempt and achieve results that might otherwise be considered too hard and beyond the state of the art. Such an approach places greater demands on instructor preparation and assistance. In a research-based graduate institution, an instructor's job is not only to guide students through new concepts and techniques, but also to enable first-hand understanding of research methodologies. Project-based grading continues to result in students producing excellent results, and thus better equips them to conduct novel thesis research using new tools and techniques. A detailed case study on this pedagogical approach is documented in the Kelp Forest paper (reference III.2.a.iii).

d. Theses

Theses advised

i. Miller, Thomas E., *Integrating Realistic Human Group Behaviors Into A Networked 3D Virtual Environment*, Master's Thesis, Naval Postgraduate School, Monterey California, September 2000. MOVES curriculum. Received NPS Outstanding Academic Achievement Award for highest academic honors among Department of Defense (DoD) students.

ii. Laflam, David W., *3D Visualization of Theater-Level Radio Communications Using a Networked Virtual Environment*, MOVES Master's Thesis, Naval Postgraduate School, Monterey California, September 2000. MOVES curriculum.

iii. Murray, Mark W. and Quigley, Jason M., *Automatically Generating a Distributed 3D Battlespace Using USMTF And XML-MTF Air Tasking Order, Extensible Markup Language (XML) and Virtual Reality Modeling Language (VRML)*, Master's Thesis, Naval Postgraduate School, Monterey California, June 2000. C^4I curriculum.

iv. Hand, Christopher E., *Testing and Development of a Low-Cost, Digital Signal Processor (DSP)-Based Torpedo Countermeasure*, Master's Thesis, Naval Postgraduate School, Monterey California, March 2000. Computer Science curriculum. Distribution limited due to patentable and militarily significant advances in technology.

v. Afonso, Francisco Carlos, *Virtual Reality Transfer Protocol (vrtp): Implementing a Monitor Application for the Real-Time Transport Protocol (RTP) Using the Java Media Framework (JMF)*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1999. Computer Science curriculum.

vi. Leaver, R. Greg, *VRML Terrain Modeling for the Monterey Bay National Marine Sanctuary (MBNMS)*, Master's Thesis, Naval Postgraduate School,

Monterey California, September 1998. Information Technology Management (ITM) curriculum.

vii. Holliday, Timothy, *Real-Time 3D Sonar Modeling and Visualization*, Master's Thesis, Naval Postgraduate School, Monterey California, June 1998. Engineering Acoustics curriculum.

viii. Kevin M. Byrne, *Real-Time Modeling of Cross-Body Flow For Torpedo Tube Recovery of the Phoenix AUV*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1998. Computer Science curriculum.

ix. Whitfield, Martin L., *Low-Cost Digital Signal Processor (DSP)-Based Torpedo Countermeasure with Autonomous Target Motion Analysis*, Master's Thesis, Naval Postgraduate School, Monterey California, June 1997. Computer Science curriculum.

x. Davis, Duane Thomas, *Precision Maneuvering and Control of the Phoenix Autonomous Underwater Vehicle for Entering a Recovery Tube*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Computer Science curriculum. Received Rear Admiral Grace Murray Hopper Computer Science Award.

xi. Burns, Michael, *Merging Virtual and Real Execution Level Software for the Phoenix Autonomous Underwater Vehicle*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Computer Science curriculum.

xii. Cummiskey, James C., *Internetworking: The Interoperability of Commercial Mobile Computers with the USMC Digital Automated Communications Terminal*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Information Technology Management (ITM) curriculum.

xiii. Courtney, Dale Michael, *Internetworking: NPS ATM LAN*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Information Technology Management (ITM) curriculum.

xiv. Dennis, Ronald Michael, *Internetworking: Integrating IP/ATM LAN/WAN Security*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Information Technology Management (ITM) curriculum.

xv. Edwards, Evan B., *Internetworking: Automated Local and Global Network Monitoring*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Information Technology Management (ITM) curriculum.

xvi. Erdogan, Ridvan, *Internetworking: Implementation of Multicasting and MBone over Frame Relay Networks*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Computer Science curriculum.

xvii. Mihlon, Lauren, *Internetworking: Multicast Videoteleconferencing over ISDN*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1996. Information Technology Management (ITM) curriculum.

xviii. Tamer, Murat, *Internetworking: Multicast and ATM Network Prerequisites for Distance Learning*, Master's Thesis, Monterey California, June 1996. Computer Science curriculum.

xix. Tiddy, Michael E., *Internetworking: Economical Storage and Retrieval of Digital Audio and Video for Distance Learning*, Master's Thesis, Monterey California, June 1996. Information Technology Management (ITM) curriculum.

xx. Nierle, James E., *Internetworking: Technical Strategy for Implementing the Next Generation Internet Protocol (IPv6) in the Marine Corps Tactical Data Network*, Master's Thesis, Monterey California, June 1996.

xxi. Stone, Steven Walter, *A Rapidly Reconfigurable, Application Layer, Virtual Environment Network Protocol*, Master's Thesis, Naval Postgraduate School, Monterey California, June 1996. Computer Science curriculum.

xxii. Leonhardt, Bradley J., *Mission Planning and Mission Control Software for the Phoenix Autonomous Underwater Vehicle (AUV): Implementation and Experimental Study*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1996. Computer Science curriculum.

xxiii. Campbell, Michael Scott, *Real-Time Sonar Classification for Autonomous Underwater Vehicles*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1996. Received Rear Admiral Grace Murray Hopper Computer Science Award. Computer Science curriculum.

xxiv. Trepanier, Dennis, *Internetworking: Designing Network Information and Operations Services for Monterey BayNet*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1995. Information Technology Management (ITM) curriculum.

xxv. Hernandez, Lance, *Analytical Simulation Evaluation of the Use of Global Positioning System (GPS) to Enhance P-3 Aircraft Tactical Capabilities*, Master's Thesis, Naval Postgraduate School, Monterey, California, March 1994. Operations Research curriculum. Includes video appendix and employs public domain NPS Platform Foundation software. Distribution limited.

xxvi. Murphy, Robert, *Tactical And Logistics Operations Simulator*, Master's Thesis, Naval Postgraduate School, Monterey, California, September 1993. Includes video appendix and IBM PC software. The program, video and user's guide produced by this thesis were developed for use in the NPS Operational Logistics curriculum.

Theses co-advised

xxvii. Ha, Yonghoon, *Java-Based Implementation of the Monterey-Miami Parabolic Equation (MMPE) Sonar Model with Enhanced Visualization and Improved Method of Environmental Definition*, Master's Thesis, Naval Postgraduate School, Monterey California, December 2000. Engineering Acoustics curriculum. Co-advisor Kevin B. Smith.

xxviii. Evans, Mark T. and Jezek, Robert J., *Testing and Development of a Low-Cost, Digital Signal Processor (DSP)-Based Torpedo Countermeasure (U)*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1998. Engineering Acoustics curriculum. Co-advisor Thomas G. Muir. Unclassified with SECRET appendix.

xxix. Harrison, M. Jordan, *Surface Ship Sensor Employment against Diesel Submarines*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1998 Operations Research curriculum. Principal advisor CAPT Wayne Hughes USN (Ret.), second reader RADM J.J. Ekelund Jr. USN (Ret.). . Runner up for the Military Operations Research Society (MORS) Stephen A. Tisdale Award for outstanding thesis work.

xxx. Glover, Mark P., *Internetworking: Distance Learning "To Sea" via Desktop Videoconferencing Tools and IP Multicast Protocols*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1998. Information Technology Management (ITM) curriculum. Primary advisor Rex Buddenberg.

xxxi. Young, Forrest C., *Phoenix Autonomous Underwater Vehicle (AUV): Networked Control of Multiple Analog and Digital Devices using LONTALK*, Master's Thesis, Naval Postgraduate School, Monterey California, December 1997. Computer Science curriculum. Co-advised with Xiaoping Yun.

xxxii. McNeal, William B., *Simulation of the Autonomous Combat Systems Robot Optical Detection System*, Master's Thesis, Naval Postgraduate School, Monterey California, December 1997. Co-advisor Gordon Schacher.

xxxiii. Jones, Doreen M., *Robot Wars Simulation*, Master's Thesis, Naval Postgraduate School, Monterey California, June 1997. Co-advisor Gordon Schacher.

xxxiv. Halvorson, Jeffrey A., *Realistic Interface and Control of a Virtual Submarine Model in NPSNET*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1997. Computer Science curriculum. Thesis advisor Michael Zyda, co-advisor with John Falby.

xxxv. Bacon, Daniel Keith Jr., *Integration of a Submarine into NPSNET*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1995. Computer Science curriculum. Thesis advisor Michael Zyda, co-advisor with John Falby.

xxxvi. Emswiler, Tracey, *Internetworking: Using the Multicast Backbone (MBone) for Distance Learning*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1995. Information Technology Management (ITM) curriculum. Co-advisor Maxine Reneker.

xxxvii. Bachmann, Eric and Gay, David, *Design and Evaluation of an Integrated GPS/INS System for Shallow-Water AUV Navigation (SANS)*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1995. Computer Science curriculum. Co-advisor Robert B. McGhee, second reader James Clynch.

xxxviii. Reimers, Stephen, *Internet Protocol over Seawater (IP/SW): Forward Error Correction (FEC) using Hamming Codes for Reliable Acoustic Telemetry*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1995. Computer Science curriculum. Co-advisor Gilbert Lundy.

xxxix. Bigelow, Randall J., *Internetworking: Planning and Implementing a Wide-Area Network (WAN) for K-12 Schools*, Master's Thesis, Naval Postgraduate School, Monterey California, June 95. Information Technology Management (ITM) curriculum. Describes in detail how local-area networks (LANs) and wide-area networks (WANs) were implemented to connect two dozen K-12 schools to the Internet. Co-advisor Rex Buddenberg.

ENIT theses co-advised. These are six-month capstone theses for fifth-year engineering students from Ecole Nationale d'Ingenieurs de Tarbes (ENIT), France. Research co-advised with Anthony J. Healey and David W. Marco.

xl. Xavier Dussourd, *Design of a Video Recording and Tracking System for the NPS Autonomous Underwater Vehicle (AUV)*, technical report NPS-ME-00-003, Naval Postgraduate School, Monterey California, August 2000.

xli. Garibal, Sebastien, *Initial Computer-Aided Design Model and Stress Analysis for the ARIES Autonomous Underwater Vehicle (AUV)*, technical report NPS-ME-99-002, Naval Postgraduate School, Monterey California, August 1999.

xlii. Piton, Gwladys, *Design and Evaluation of a Differential Global Positioning System (DGPS) for the NPS Autonomous Underwater Vehicle (AUV)*, technical report NPS-ME-99-003, Naval Postgraduate School, Monterey California, August 1999.

xliii. Lalaque, Samuel, *Design of a Power Bus for a Autonomous Underwater Vehicle (AUV)*, technical report NPS-ME-00-004, Naval Postgraduate School, Monterey California, August 1999.

xliv. Doléac, Joël, *A Graphic User Interface (GUI) for Generating NPS Autonomous Underwater Vehicle (AUV) Execution Script Files*, technical report NPS-ME-99-005, Naval Postgraduate School, Monterey California, August 1999.

xlv. Beguery, Laurent and David, Alexandre, *LonWorks Technology for a Control Network onboard the Phœnix AUV*, technical report NPS-ME-98-00x, Naval Postgraduate School, Monterey California, August 1998.

xlvi. Moreau, Jean-Etienne, *Surface Forces and Real-Time Hydrodynamic Modeling for the Phœnix AUV*, technical report NPS-ME-98-00x, Naval Postgraduate School, Monterey California, July 1998.

Theses second reader

xlvii. Diaz, J. Enrique Reyes, *Assigning Unmanned Undersea Vehicles (UUVs) to Mine Detection Operations, Master's Thesis*, Naval Postgraduate School, Monterey California, December 1999. Operations Research curriculum. Advisor Rob Dell.

xlviii. Murray, Don C. and Pratt, Christopher L., *Remote Network Administration of the SeaNet Communication Node System*, Master's Thesis, Naval Postgraduate School, Monterey California, June 1997. Information Technology Management (ITM) curriculum. Advisor Rex Buddenberg.

xlix. Shirasaka, Masahide, *Optimizing Safe Motion for Autonomous Vehicles*, Master's Thesis, Naval Postgraduate School, Monterey California, September 1994. Computer Science curriculum. Advisor Yutaka Kanayama, other second reader Gordon Bradley.

Doctoral committees

l. Abrams, Howard, *Extensible Interest Management for Scalable Persistent Distributed Virtual Environments*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, December 1999. Committee member. Advisor Michael Zyda.

li. Bachmann, Eric, *Inertial and Magnetic Angle Tracking of Limb Segments for Inserting Humans into Synthetic Environments*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, October 2000. Committee member. Advisor Michael Zyda.

lii. Capps, Mike, *Fidelity Optimization in Distributed Virtual Environments*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, June 2000. Committee member. Advisor Michael Zyda. I continue to collaborate and work with Dr. Capps in his new role as Research Assistant Professor.

liii. Gautier, Laurent, *Une Architecture de Communication pour les Applications Multi-utilisateurs Interactives Distribuées sur Internet (A Communications Architecture for Multi-user Interactive Applications Distributed across the Internet)*, Ph.D. Dissertation, Institut National de Recherche en Informatique et en Automatique (INRIA), Sophia Antipolis France, September 1998. Committee member. Advisor Christophe Diot.

liv. Storms, Russell, *Auditory-Visual Cross-Modal Perception Phenomena*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, September 1998. Committee member. Advisor Michael Zyda.

e. Self-improvement efforts. Include any attendance at workshops and conferences to improve any aspect of instruction, any auditing courses at NPS or elsewhere, etc.

i. French language. In order to collaborate effectively with French researchers, I have redeveloped my French reading and speaking abilities. I am now capable of reading and reviewing complex documents such as papers and dissertations. I am close to having adequate conversational capability for daily life in France. My previous exposure to foreign languages is three years of French and three years of Latin during junior high and high school 1970-1974. My family and I are considering a sabbatical in France as a future possibility. My efforts to learn French have helped support several ongoing research collaborations.

ii. Menneken lecture series. I regularly contribute as a speaker and invite guest lecturers to the Menneken lecture series on Mine Warfare offered by the Undersea Warfare Academic Group.

iii. MOVES lecture series. I regularly contribute as a speaker and invite guest lecturers to the technical lecture series on 3D graphics and related techniques offered by the MOVES Academic Group.

iv. Demonstrations. Both the MOVES group and the NPS Center for AUV research remain in high demand as showcase research efforts at NPS. Each week one or both research groups typically conduct demonstrations for visiting researchers and dignitaries. Occasionally major demonstration opportunities occur: Discovery Day, National Oceans Conference, symposia hosted at NPS, etc. I typically prepare by finding out the background and research interests of our visitors so that collaboration opportunities can be explored knowledgably. Attending such demonstrations is time consuming but frequently yields unexpected questions and insights. Speaking and listening while demonstrating software capabilities is an acquired skill. Preparing students to present such demonstrations is an essential capability that we encourage, thereby enabling their thesis endeavors to achieve successful impacts.

v. Conferences and technical visits. I typically travel once or twice per month, either to an academic conference or a research-related meeting. Many topics in graphics, networking and robotics change quite rapidly, so active participation is necessary for our NPS research efforts to remain current and effective. Such participation is especially important when collaborating with multiple external partners, building technologies intended to scale technically and socially with the World Wide Web.

f. Reading courses taught. List quarter and year, number of students, and subject.

i. Design patterns and Unified Modeling Language (UML). Summer 1999 directed group study for six masters and Ph.D. students including staff. Examined recent

work in formally identifying and normalizing programming patterns that have emerged from years of successful software-engineering practice. Use of design patterns and UML has improved the performance and robustness of NPS-developed software. More work is needed to fully integrate these software-engineering strengths into NPS curricula. Texts:

Gamma, Erich, Helm, Richard, Johnson, Ralph and Vlissides, John, *Design Patterns: Elements of Reusable Object-Oriented Software*, Addison-Wesley, Reading Massachusetts, 1995.

Grand, Mark, *Patterns in Java*, vol. 1, John Wiley & Sons, New York, 1998.

Fowler, Martin with Scott, Kendall, *UML Distilled*, first edition, Addison-Wesley, Reading Massachusetts, 1998. (Now in second edition, 2000.)

g. Instructional materials. List any materials prepared and updated, any courses administered.

i. Course administered. Varma, Anujan Ph.D., *Introduction to ATM*, 8-video course and notes purchased from University of California Santa Cruz (UCSC) and the Stanford Center for Professional Development. Six students attended. This course provided fundamental material enabling multiple student theses and NPS participation in the regional Monterey Bay ATM-based California Research and Education Network (CALREN) underwritten by Pacific Bell. Partners included UCSC, UCSC Extension Santa Clara, Tech Museum of Innovation San Jose, Monterey Bay Aquarium (MBA), and Monterey Bay Aquarium Research Institute (MBARI). Several costly and important lessons regarding use of ATM-based technologies were learned and reported in writing to the NPS administration. Unfortunately these reports were ignored when upgrading the campus fiber network in 1998, resulting in significant and continued barriers to high-performance network research at NPS.

h. Mentoring. I have worked with a number of Ph.D. candidates, providing significant direction or support regarding their efforts. In addition to the dissertation committees listed earlier, I have worked with the following collaborators and staff members.

i. Blais, Curtis, joint appointment as research associate and Ph.D. student in the Institute for Joint Warfare Analysis (IJWA) and MOVES. His research interests include advanced simulation technologies, agents and networked virtual environments in the MOVES doctoral program. Curtis has 25 years experience in

combat modeling plus command and control simulations for a variety of Navy and Marine Corps programs.

ii. DelTheil, Caroline, *Une Metholodolgie pour l'Analyse et la Modelisation Causales de Systemes Hydrides Complexes Application a la Modelisation Comportementale d'un Vehicule Sous-marin Autonome (A Methodology for Analyzing and Simulating Dynamics of Complex Hybrid Systems, Applied to the Modeled Behavior of an Autonomous Underwater Vehicle)*, Ph.D. Dissertation, University of Paris no. 6, France, 1998. Provided extensive advise and software for use of an underwater virtual world as an enabling technology. For simulating synthetic vision to test an optical guidance system for the recovery of an AUV.

iii. Macedonia, Mike, *A Network Software Architecture for Large-Scale Virtual Environments*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, June 1995. We were Ph.D. students together at NPS, I assisted in design and conduct of dissertation experiments.

iv. Marco, Dave, *Autonomous Control of Underwater Vehicles and Local Area Maneuvering*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, September 1996. Long-term collaborator on robot hardware/software development.

v. McGregor, Don, staff member and research faculty, 1997-present. Daily and weekly collaboration on research programming, project design, strategic planning and course teaching. Supported his promotion to adjunct research faculty, encouraging his ongoing shared and independent research efforts.

vi. Riedel, Jeffrey S., *Seaway Learning and Motion Compensation in Shallow Waters for Small AUVs*, Ph.D. Dissertation, Naval Postgraduate School, Monterey California, June 1999. Assisted in simulation design and development.

vii. Watsen, Kent, *Bamboo: A Platform- and Language-Independent Mechanism Enabling Dynamically Reconfigurable Applications*, Ph.D. student on leave of absence. Committee member.

viii. Zolla, George, ITM Ph.D. student. As the non-ITM member of George's committee I have provided extensive technical advice and feedback regarding his research on the impact of information technology on organizational effectiveness.

i. Course coordination. List any courses requiring significant efforts to coordinate.

i. UW3303. The Introduction to Modeling and Simulation course for Undersea Warfare (UW) students has always been difficult to coordinate with other curricular demands. Negative factors include loss of a prerequisite programming course, diverse student backgrounds and variable enrollment. Project-based instruction with a classroom mix of programmers and nonprogrammers is difficult. NPS software laboratory support remains very uneven, raising the difficulty level for new

students. Notional instruction on theoretical simulation concepts without direct student involvement developing example simulation programs is of little value. Fortunately, use of MatLab in the most recent iteration of this course appears to provide an excellent resolution to these quandaries. Both unfamiliar and experienced students are now able to perform realistic simulation projects geared to help them in other diverse UW courses.

j. Other instruction information. Describe any other contributions to instruction that might be relevant.

   i. I have actively participated in UW and MOVES curriculum development for many years. My experience in the Operations Research Department had a positive impact on developing a MOVES curriculum with significant Computer Science and Operations Research components. I frequently suggest and implement innovative new course material, often on emerging and under-development technologies..

k. Other information on evaluation of instruction. Include any evaluation material that you may wish to offer that demonstrates effectiveness of instruction.

   i. DIS course evaluations

   ii. SIGGRAPH course evaluations

2. Internal Research Activities

a. Summary of research projects

i. *Regional BeachLab Refurbishment Planning*, AT+T Pebble Beach Foundation ($20,000), principal investigator Don Brutzman. Oversight and assistance from the NPS Foundation. Prepare preliminary design and environmental assessment planning, together with architectural landscape and building diagrams, to visualize possible refurbishment of NPS beachfront property on Del Monte Beach as a combination classroom/wetlab teaching facility for S.E.A. Lab Monterey Bay. Requires coordination with numerous NPS and regional institutions.

ii. *Networked Virtual Environments: 3D VR Web Browser, Dynamic Behavior Protocol (DBP), and VRTP Development*, Navy Modeling and Simulation Office N6M ($34,000), principal investigator Don Brutzman. Continue development of open-source Java3D-based Web browser for VRML/X3D scenes, with integration of DBP/DIS-Java-VRML functionality. This work eliminates dependence on uncertain commercial browser efforts and enables the possibility of requiring script support for standards compliance in future VRML 200x browsers.

iii. *Human-Computer Interaction: Enhanced Capabilities in the MOVES CAVE Facility*, Navy Modeling and Simulation Office N6M ($63,750), investigators Rudy Darken, Don Brutzman and Russell Shilling. Continued MOVES CAVE hardware/software development boosting interactivity and frame rate in this showcase display room.

iv. *Scenario Authoring and Visualization using Advanced Graphical Environments (SAVAGE)*, Marine Corps Combat Development Command, September 2000- August 2002 ($250K annually), principal investigator Curtis Blais with Don Brutzman. We will model and demonstrate a full amphibious invasion, as exemplified by using real-world exercise operational orders and 2D visualizations such as Marine Air-Ground Task Force (MAGTF) Tactical Warfare Simulation (MTWS) software, augmented by dynamic 3D visualizations using DIS-Java-VRML models.

v. *Operations Integration Working Group (OIWG) Participation*, Program Executive Office (PEO) for Undersea Warfare Advanced Systems and Technology Office (ASTO), 1 February 2000-31 January 2001 ($39,000), principal investigator Don Brutzman. Evaluate and advise on advanced tactical build software interfaces for next-generation submarine combat control systems.

vi. *Streaming 3D Graphics Using vrtp for Distributed Simulation*, Defense Threat Reduction Agency (DTRA), July 2000- June 2001 ($80K annual), co-investigator with Mark Pullen and Robert Simon of George Mason University (GMU). Further develop NPS simulation techniques for distributed 3D graphics, in concert with reliable multicast and High-Level Architecture interface efforts at GMU, in support of physics-intensive distributed simulations for DTRA.

vii. *Remote Operated Vehicle (ROV) Data Visualization*, Monterey Bay Aquarium Research Institute (MBARI), voluntary, October 1998-present. Principal investigator Mike McCann MBARI. I have served in an advisory role for MBARI's successful efforts to capture and convert ROV dive data for integration and viewing in a VRML-based 3D environment, complete with color-mapped bathymetry, customizable on user demand.

viii. *Development of National Tele-Immersion Initiative (NTII) Applications and virtual reality transfer protocol*, Advanced Networks and Services, 1988-1999 ($840,000)**,** principal investigators Mike Zyda and Don Brutzman. Worked to develop WAN-connected high-performance virtual reality applications with NTII partners. Research focused design and initial implementation of vrtp behavior streaming stack. Supported additional staff Ph.D.-research efforts in building architecture-independent software components and Area of Interest Management (AOIM) networking mechanisms.

ix. *AUV Tactical Decision Aids using Modeling and Simulation,* Office of Naval Research (ONR), 1998-present (1 quarter salary annually), principal investigator Tony Healey with Dave Marco and Don Brutzman. Demonstrate near-real-time conversion of telemetry and imagery from a variety of AUV platforms, each performing shallow-water mine hunting, into naval messages for use by the Mine Warfare Environmental Database and Library (MEDAL). MEDAL is a software component of the maritime segment for the Global Command and Control System (GCCS-M).

x. *Tactical Visualization of the Environment: Manta Minefield Search*, 1997 (one quarter of salary), Naval Undersea Warfare Center (NUWC), Newport Rhode Island, principal investigator Don Brutzman. Developed and integrated VRML 3D modeling, analytic simulation and real-time hydrodynamics models to demonstrate how tactical visualization of real-world environments can provide significant insights into robot system development and tactical deployment.

xi. *Development of a Low-Cost DSP-Based Acoustic Countermeasure*, Office of Naval Research (ONR), $8,000 in 1997 and $14,000 in 1998 (no salary) for circuit design and equipment purchase. Supported four thesis students.

xii. *Enabling decision support technology for JTF Crisis Operations as part of DoD Joint Task Force (JTF) Advanced Technology Demonstration (ATD) and DARPA/DISA Joint Projects Office (JPO) Leading Edge Services (LES),* awarded by DARPA and NPS Institute for Joint Warfare Analysis (IJWA), 1 OCT 96-30 SEP 97 (1 month salary provided), principal investigator Dan Boger (C3) with Tung Bui (SM), Bill Kemple (C3), Don Brutzman (UW) and Gary Porter (C3). Examined WAN connections between NPS and SPAWAR San Diego California. Under my supervision, five thesis students participated in LAN/WAN/ATM connectivity efforts.

xiii. *Rapidly Reconfigurable Virtual Environment Network Protocols*, Office of Naval Research (ONR), 1 OCT 95-30 SEP 98 ($415K), principal investigator Mike Zyda and Don Brutzman. Performed initial examination of reconfigurable network protocols, provided one-quarter salary, documented in Stone thesis, terminated satisfactorily after one year due to ONR funding reductions and program priorities restructuring.

xiv. *NPS Mobile Computing and Communications Research Group,* USMC Systems Command, 1 JAN 96-30 SEP 96 ($25K), principal investigator Don Brutzman with James Cummiskey and David Duff. Developed and tested interoperable wireless networked palmtop computer software in support of USMC platoon leaders. Documented in Cummiskey thesis.

xv. *Distributed Interactive Simulation (DIS) Overview Course*, ORSA Continuing Education Program and Army Logistics Management College Fort Belvoir Virginia, 15 NOV 95-30 FEB 96 ($11K), principal investigator Don Brutzman. Produced and provided 4-day short course on use of DIS protocol in military simulations.

xvi. *Multicast Backbone (MBone) Audio and Video Demonstration for the New Attack Submarine (NSSN) Open System Critical Item Test (OSCIT)*, 3 MAR 95-30 SEP 95 ($10K), Naval Undersea Warfare Center (NUWC), Newport Rhode Island, principal investigator Don Brutzman. Configured computer systems and demonstrated use of multicast audio/video plus AUV underwater virtual world as part of Commercial Off-the-Shelf (COTS) computer workstations used during this NSSN design-evaluation milestone.

xvii. *Air Interoperability Center (AIC) Platform Foundation*, JAN 95-30 SEP 95 ($35K), Naval Air Warfare Center (NAWC) Patuxent River Maryland, principal investigator Mike Bailey with Don Brutzman. My task was to port legacy C/C++ DIS software libraries from SGI workstations to Sun workstations, in order to run with the MODSIM-based NPS Platform Foundation. Limited success, numerous lessons learned and applied in later DIS-Java-VRML development.

xviii. *Building a Large-Scale Virtual World for Monterey Bay*, 3 JAN 95-31 DEC 96 ($18K plus four quarters labor), Research Initiation Project (RIP) awarded by NPS, principal investigator Don Brutzman. During this work period I devised the architectural foundation for large-scale graphics-based 3D scenes and many-to-many internetworked behavior streaming that we continue to develop and implement today as VRML/X3D and vrtp.

b. Thesis Contributions. Describe any contributions to the research efforts of NPS student theses beyond those listed in Section II.1.d.

i. Rodrigues Neto, Jose Augusto, *A Mine Search Algorithm for the NPS AUV*, Master's Thesis, Naval Postgraduate School, Monterey California, December 1994. Operations Research and Computer Science curricula. Advisors Gordon Bradley and Robert McGhee, second reader James Eagle.

While a Ph.D. student, I spent extensive time helping Jose develop search algorithm implementations and simulations for this thesis. I also provided advice enabling him to simultaneously complete master's degrees in Operations Research and Computer Science.

ii. Gambrino, John Robert, *An Analysis of Internet's MBone: A Media Choice Perspective*, Master's Thesis, Naval Postgraduate School, Monterey California, March 1996. Information Technology Management (ITM) curriculum. Advisor James E. Suchan.

A media-effectiveness evaluation was performed during preparations for the global Hamming lecture series, analyzing multicast sessions used for regional educational collaborations. Questions and lessons learned in this thesis provided valuable preparation for the Hamming lecture series, as well as feedback for subsequent distance-learning instruction.

c. Contributions to interdisciplinary NPS research projects. Describe any contributions to interdisciplinary research. Also include any development of research facilities used for interdisciplinary work.

i. NPS Center for AUV Research. I have been working and associated with Tony Healey's AUV efforts since first arriving at NPS as a student in 1990. This is a world-class laboratory working on topics of direct value to the Navy and (someday) industry.

ii. Graphics (now MOVES) Group. I have similarly been working and associated with Mike Zyda's virtual reality (VR) efforts since first arriving at NPS as a student in 1990. This is a world-class laboratory working on topics of direct value to the Department of Defense and industry.

iii. Beachlab facility. For eight years I have proposed and worked towards development of a regional seawater research laboratory and classrooms, through refurbishment of unused sewage treatment tanks and a defunct chlorination building on Navy beachside property. Numerous letters of support have been received regarding this effort, including endorsements from dozens of regional scientists and educators as well as Congressman Sam Farr. Partnerships with S.E.A. Lab Monterey Bay, MATE, and other programs can maximize educational and mentoring activities. If funded and executed, regional researchers will be able to conduct a wide range of scientific studies with fish, marine mammals, kelp, autonomous underwater vehicles, sonars, underwater video, diver training, current convection analysis, fisheries restoration, etc., all with student observation and participation. Critical support has been provided over the years by Professor Tony Healey, Associate Professor Jeff Paduan, Dean of Research David Netzer, Provost Richard Elster, Alynn McGuire of NPS Public Works, Mr. Fred Cohn of Monterey city staff, and NPS Superintendents RADM Thomas W. Mercer USN (Ret.) and RADM Robert C. Chaplin USN. I continue to actively pursue development and funding opportunities for this important facility.

d. Visiting researchers attracted.

i. Olivier Doucy, Sirhena SA of Nantes, France, August 1999-July 2000. This exceptionally competent senior engineer spent a full year at NPS working on sophisticated AUV control in the presence of surface waves, visualized using underwater virtual world. He also assisted in teaching, software development, ENIT exchange student mentoring and in-water testing. M. Doucy played a key role in developing and testing a software interface between MatLab and DIS-Java-VRML. He is principal author on a joint paper documenting progress and test results (refereed conference paper xiii).

ii. Ronan Fauglas, University of Paris, France, September 1997-March 1998. Spent six months developing an automatic translator for DIS enumerations. This script written in the *perl* language converts many dozens of tabular Web pages into Java source code. These Java classes are then compiled and used as human-readable variable names corresponding to encoded values for vehicle types, countries of the world and dozens of other attributes. This mil.nps.navy.mil.disEnumerations

package is available at http://www.web3D.org/WorkingGroups/vrtp/dis-java-vrml/SoftwareReference.html#disEnumerations

iii. Antonio Alexandre Rua, University of Porto, Portugal, June-September 1997. Authored Java source code for the Simulation Management family of DIS PDUs and assisted in the NPS AUV research group. Java source available in the mil.nps.navy.mil.dis package at http://www.web3d.org/WorkingGroups/vrtp/dis-java-vrml/ SoftwareReference.html#dis and http://www.web3D.org/WorkingGroups/vrtp/javadoc/dis-java-vrml/mil/navy/nps/dis/package-tree.html

iv. ENIT. Following an invitation to collaborate by Dr. Didier Leandri, I worked with him to negotiate, staff and execute a Memorandum of Agreement (MOA) between NPS and Ecole Nationale d'Ingenieurs de Tarbes (ENIT), France. Preparations included a visit to Tarbes (funded by ENIT) for program planning. Collaborating ENIT researchers are Dr. Didier Leandri (1997-1999) and Dr. Thierry Vidal (2000-present). NPS role is to serve as a capstone industry or university setting for fifth-year engineering students to complete a capstone project comparable to a master's thesis. This program has been very successful, both for ENIT and NPS. Eight exchange students have successfully completed tours at NPS during the interval 1997-2000 and their work is listed under co-advised theses. Student supervision duties shared with Dr. Tony Healey and Dr. David Marco.

3. Internal Administrative and Service Activities

a. Committee Service. List NPS faculty committees and councils, department committees, and administrative service activities. Indicate level of effort, and significant contributions.

i. Computer Science Graphics track and MOVES curriculum committees. Regularly review and advise on required and optional student course requirements.

ii. MOVES Group Ph.D. Committee. Helped develop the first-ever Ph.D. program for MOVES Ph.D. students. Continuing to advise as we mentor our first candidates under this program. Available online at http://www.npsnet.org/~moves/PhD.html

iii. MOVES Executive Committee. Support the MOVES Academic Group chair by considering issues and solutions relating to this new curriculum, enabling focused discussion to follow among this larger group (over two dozen faculty).

iv. Faculty council. Appointed as MOVES representative October 2000.

b. Service as Academic Associate. I am Alternate Academic Associate for the MOVES Academic Group, serving as backup for Rudy Darken. I further ensure that all of my thesis students select and schedule their courses to best support pertinent topics of interest in their thesis investigations.

c. Activities in Academic Groups. I am one of the three initial tenure-track faculty assigned solely to the academic groups. My group service and accomplishments include the following areas, and are documented elsewhere in this document.

i. Cross-disciplinary research: AUV, MOVES and various theses
ii. Support of mine warfare symposia at NPS in 1996 and 1998
iii. Annual UW and MOVES curriculum reviews
iv. Supporting other undersea warfare courses with UW3303
v. Participation in the 1998 NPS Network-Centric UW (NCUW) workshop
vi. Long-term collaborative efforts to maintain Navy relevance, including NPS Memorandum of Understanding with Commander, Submarine Development Squadron TWELVE.

III. EXTERNAL ACTIVITIES

1. External Teaching Activities

   a. Courses

      i. SIGGRAPH. *Internetworked 3D Graphics: Bottlenecks and Breakthroughs*. This is a collaboration effort with Theresa-Marie Rhyne of the U.S. Environmental Protection Agency, Robert Barton of Fraunhofer Center for Research in Computer Graphics (CRCG), and Michael Macedonia of U.S. Army STRICOM. We have taught this course for four years at the annual SIGGRAPH conference, with attendance gradually growing from 200 to 400. Our course notes are available online and also distributed via CD to several thousand attendees and SIGGRAPH members. Locations included Los Angeles California, New Orleans Louisiana and Orlando Florida. SIGGRAPH is the premiere academic and industry 3D graphics conference with 35,000 - 45,000 attendees yearly.

      ii. SIGCOMM. We presented a well-received version of this course at SIGCOMM 97 in Sophia-Antipolis France, focusing on the differences of 3D graphics compared to other streamed media types when considered from a network perspective. SIGCOMM is the premiere academic networking conference with 200-300 attendees yearly.

      iii. DS-RT 2000, Fourth IEEE International Workshop on Distributed Simulation and Real Time Applications (DS-RT), August 24 2000, San Francisco California. I presented a DIS-Java-VRML tutorial to 8 of 25 attendees.

      iv. Web3D/VRML 2000, February 2000, Monterey California. Don McGregor and I together provided a tutorial on using and extending DIS-Java-VRML applications.

      v. OCEANS 97 and 98, IEEE Oceanic Engineering Society (OES) annual conference, provided a tutorial on using the Virtual World for an Autonomous Underwater Vehicle.

   b. Course materials used at other universities, title, number of places used.

      i. I have no direct knowledge of these course materials being used at other universities, but their distribution is widespread and available online.

   c. Other significant products used externally for instruction, such as computer-aided instruction case studies, laboratory experiments, computer design/graphics products, etc.

i. VRML examples. The project *Visualization of the Tactical Environment: Manta Minefield Search* created several important results. One research product included a storyboard scenario for use of multiple offboard underwater robots used by a submarine to search a hostile minefield. Video vignettes complement a set of HTML pages which mimic a powerpoint slide set, with each 2D slide having a corresponding 3D scene behind it which illustrates the concepts described. Distribution limited, available on request.

ii. X3D examples. I translated an extensive set of 300+ example 3D scenes demonstrating use of the X3D tagset, including all examples in the ISO-approved VRML 97 specification. This effort helps verify features of the X3D tagset and also helps to improve the context-sensitive tooltips in the X3D-Edit authoring tool. These examples include a full set of annotated translations for the *VRML 2.0 SourceBook* (by Moreland, Nadeau, and Ames). Available online at http://www.web3D.org/TaskGroups/x3d/translation/examples/examples.html and http://www.web3D.org/TaskGroups/x3d/translation/examples/Vrml2.0Sourcebook

d. Short course initiation, coordination and participation. Include hours of instruction, where offered, when offered, evaluation results by course sponsors and attendees, and a summary statement of the responsibility of candidate.

i. In February 1996 I presented a short course on use of the DIS protocol in military simulation systems to Army logistics experts at Fort Belvoir Virginia. This work was created and performed under a 3-month research contract. The course received excellent participation and feedback from students, but was hampered by the lack of portability of our DIS implementations at that time (C/C++ source on Irix operating systems only). This short-term success with no long-term follow-through was another motivating factor to develop the DIS-Java-VRML software library.

e. Distance Learning course initiation, coordination and participation. Include hours of instruction, where offered, when offered, evaluation results by course sponsors and attendees, and a summary statement of the responsibility of candidate.

2. External Research Activities

a. Products distributed outside NPS

Book chapters

i. Brutzman, Don, Healey, Tony, Marco, Dave and McGhee, Bob, "The Phoenix Autonomous Underwater Vehicle," chapter 13, *AI-Based Mobile Robots*, editors David Kortenkamp, Pete Bonasso and Robin Murphy, MIT/AAAI Press, Cambridge Massachusetts, 1998.

ii. Brutzman, Don, "Graphics Internetworking: Bottlenecks and Breakthroughs," chapter four, *Digital Illusions*, Clark Dodsworth editor, Addison-Wesley, Reading Massachusetts, August 1997.

Refereed journal papers/cases under review

iii. Brutzman, Donald P., "Teaching 3D Modeling and Simulation: Virtual Kelp Forest Case Study," in submission to *IEEE Computer Graphics + Applications*, December 1999. Status: responding to first round of reviewer comments.

Refereed journal papers/cases

iv. Brutzman, Donald P., Whitfield, Martin L., Evans, Mark T., Jezek, Robert J., Jr. and Hand, Christopher E., "Design of a Low-Cost Torpedo Countermeasure Based on a Digital Signal Processor (DSP) (U)," *Journal of Underwater Acoustics (JUA)*, vol. 49 no. 3, July 1999, pp. 711-722.

v. Deltheil, Caroline, Leandri, Didier, Hospital, Eric and Brutzman, Donald P., "Simulating an Optical Guidance System for the Recovery of an Unmanned Underwater Vehicle," *IEEE Journal of Oceanic Engineering*, accepted for publication 2000.

vi. Capps, Michael, McGregor, Don, Brutzman, Don and Zyda, Michael, "NPSNET-V: A New Beginning for Virtual Environments," *IEEE Computer Graphics + Applications*, vol. 20 no. 5, September-October 2000, pp. 12-15.

vii. Brutzman, Don, "The Virtual Reality Modeling Language and Java," *Communications of the ACM*, vol. 41 no. 6, June 1998, pp. 57-64.

viii. Wheless, Glen H., LaScara, Cathy M., Valle-Levison, Arnaldo, Brutzman, Donald P., Sherman, William, Hibbard, William L. and Paul, Brian E., "Chesapeake Bay Virtual Ecosystem Model (CBVEM): initial results from the prototypical system," *International Journal of Supercomputer Applications*, Sage Science Press, vol. 10 no. 2/3, Summer/Fall 1996, pp. 199-210.

ix. Wheless, Glen H., Lascara, Cathy M., Valle-Levinson, Arnoldo, Brutzman, Donald P., Sherman, William, Hibbard, William L. and Paul, Brian E., "Virtual Chesapeake Bay: Interacting with a Coupled Physical/Biological Model," *IEEE Computer Graphics + Applications*, vol. 16 no. 4, July 1996, pp. 52-57.

x. Macedonia, Michael R., Zyda, Michael J., Pratt, David R., Brutzman, Donald P., and Barham, Paul T., "Exploiting Reality with Multicast Groups," *IEEE Computer Graphics + Applications*, vol. 15 no. 5, September 1995, pp. 38-45.

xi. Macedonia, Michael R. and Brutzman, Donald P., "MBone Provides Audio and Video Across the Internet," *IEEE COMPUTER*, vol. 27 no. 4, April 1994, pp. 30-36.

Nonrefereed journal papers/cases

xii. Don Brutzman and Timothy Childs, guest editors, "Web3D Roundup: Looking Backwards and Forwards," special issue *COMPUTER GRAPHICS*, Association of Computing Machinery (ACM) Special Interest Group on Graphics (SIGGRAPH), July 2000. Introduction pp. 35-36, Kelp Forest project pp. 48-49, writeups of 28 other contribution presentation solicited and presented 1997-2000 pp. 37-68. Essentially we have created a major new presentation forum for demonstration of real-time 3D graphics. This special issue documents three years of accomplishments. External review performed by Gordon Cameron, editor-in-chief of *COMPUTER GRAPHICS*, pp. 4-5. This event is now officially incorporated as a regular program feature in the annual ACM SIGGRAPH conference.

Refereed conference papers

xiii. Doucy, Olivier, Brutzman Don and Healey, Tony, "Near-Surface Manoevring and Station Keeping for an Autonomous Underwater Vehicle," NATO Advanced Technologies Symposium, Applied Vehicle Technology Panel, Ankara Turkey, October 23-39 2000.

xiv. Oliveira, Manuel, Crowcroft, Jon, Slater, Mel and Brutzman, Don, "Components for Distributed Virtual Environments," *ACM Symposium on Virtual Reality Science and Technology (VRST 99)*, University College London (UCL), London England, December 20-22 1999, pp. 176-177.

xv. Rhyne, Theresa-Marie, Brutzman, Don and Macedonia, Michael, "Internetworked Graphics and the Web," *IEEE COMPUTER*, vol. 30 no. 8, August 1997, pp. 99-101.

xvi. Brutzman, Don, Zyda, Mike, Watsen, Kent and Macedonia, Mike, "virtual reality transfer protocol (vrtp) Design Rationale," *Workshops on Enabling Technology: Infrastructure for Collaborative Enterprises (WET ICE): Sharing a*

Distributed Virtual Reality, Massachusetts Institute of Technology, Cambridge Massachusetts, June 18-20 1997.

xvii. Storms, Russell, Biggs, Lloyd, Cockayne, William, Barham, Paul, Falby, John, Brutzman, Don and Zyda, Michael, "The NPS Auralization and Acoustics Laboratory," *Proceedings of the International Conference of Auditory Displays (ICAD)*, Palo Alto California, November 1996.

xviii. Brutzman, Don, Zyda, Mike and Macedonia, Mike, "Cyberspace Backbone (CBone) Design Rationale," *15th DIS Workshop on Standards for the Interoperability of Distributed Simulations*, Institute for Simulation and Training, Orlando Florida, September 16-20 1996, paper 96-15-99.

xix. Brutzman, Don, Burns, Mike, Campbell, Mike, Davis, Duane, Healey, Tony, Holden, Mike, Leonhardt, Brad, Marco, Dave, McClarin, Dave, McGhee, Bob and Whalen, Russ, "NPS Phoenix AUV Software Integration and In-Water Testing," *IEEE Oceanic Engineering Society Conference AUV 96*, Monterey California, June 3-6 1996.

xx. Cockayne, William, Zyda, Michael, Barham, Paul, Brutzman, Don and Falby, John, "The Laboratory for Human Interaction in the Virtual Environment," *Proceedings of Virtual Reality Science and Technology (VRST) Symposium 1996*, Hong Kong, ACM Press.

xxi. Stone, Steve, Zyda, Mike, Brutzman, Don and Falby, John, "Mobile Agents and Smart Networks for Distributed Simulations," *14th DIS Workshop on Standards for the Interoperability of Distributed Simulations*, Institute for Simulation and Training, Orlando Florida, March 11-15 1996, paper 96-14-133, pp. 909-917.

xxii. Brutzman, Donald P., Macedonia, Michael R. and Zyda, Michael J., "Internetwork Infrastructure Requirements for Virtual Environments," *First Annual Symposium of the Virtual Reality Modeling Language (VRML 95)*, sponsored by ACM SIGGRAPH, San Diego California, December 14-15, 1995.

xxiii. Wheless, Glen, LaScara, Cathy, Valle-Levison, Arnaldo, Brutzman, Don and Sherman, Bill, "Chesapeake Bay Virtual Ecosystem Model (CBVEM): Interacting with a Coupled Bio-Physical Simulation," *IEEE/ACM Supercomputing 95*, San Diego California, December 3-7 1995.

xxiv. Bible, Steven R., Zyda, Michael and Brutzman, Don, "Using Spread-Spectrum Ranging Techniques for Position Tracking in a Virtual Environment," *Second IEEE Workshop on Networked Realities*, Boston Massachusetts, October 26-28 1995.

xxv. Brutzman, Don, "Virtual World Visualization for an Autonomous Underwater Vehicle," *Proceedings of the IEEE Oceanic Engineering Society Conference OCEANS 95*, San Diego California, October 12-15 1995, pp. 1592-1600.

xxvi. Brutzman, Don and Reimers, Stephen, "Internet Protocol over Seawater (IP/SW): Towards Interoperable Underwater Networks," *Ninth International Symposium on Unmanned Untethered Submersible Technology (UUST) 95*, University of New Hampshire, Durham New Hampshire, September 25-27 1995, pp. 444-457.

xxvii. Brutzman, Donald P., "Remote Collaboration with Monterey Bay Educators," *Interactive Communities Visual Proceedings, Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH 95)*, Los Angeles California, August 7-11 1995, p. 145.

xxviii. Brutzman, Donald P., "Networked Ocean Science Research and Education, Monterey Bay California," *INET 95: Fifth Annual Conference of the Internet Society*, Honolulu Hawaii, June 27-30 1995.

xxix. Bailey, Michael P. and Brutzman, Donald P., "The NPS Platform Foundation," Proceedings of the Ninth European Simulation Multiconference, Prague, Czech Republic, June 5-7 1995.

xxx. Macedonia, Michael R., Brutzman, Donald P., Zyda, Michael J., Pratt, David R., Barham, Paul T., Falby, John and Locke, John, "NPSNET: Demonstration of a Multi-Player Virtual Environment Over the Internet," *1995 Symposium on Interactive 3D Graphics, Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH)*, Monterey California, April 10-12 1995.

xxxi. Macedonia, Michael R., Zyda, Michael J., Pratt, David R., Brutzman, Donald P. and Barham, Paul T., "Exploiting Reality with Multicast Groups: A Network Architecture for Large-Scale Virtual Environments," *IEEE Virtual Reality Annual International Symposium (VRAIS)*, Research Triangle Park, North Carolina, March 11-15 1995.

xxxii. Healey, A., Marco, D., McGhee, R., Brutzman, D. and Cristi, R., "A Tri-Level Hybrid Control System for the NPS Phoenix Autonomous Underwater Vehicle," *Joint US/Portugal Workshop in Undersea Robotics and Intelligent Control*, Lisboa Portugal, March 2-3 1995.

xxxiii. Healey, A.J., Marco, D.B., McGhee, R.B., Brutzman, D.P., Cristi, R., Papoulias, F.A., and Kwak, S.H. "Tactical/Execution Level Coordination for Hover Control of the NPS AUV II using Onboard Sonar Servoing," *Proceedings of the IEEE Oceanic Engineering Society Conference Autonomous Underwater Vehicles (AUV) 94*, Cambridge Massachusetts, July 19-20, 1994, pp. 129-138.

xxxiv. Brutzman, Donald P., "Beyond intelligent vacuum cleaners," *American Association for Artificial Intelligence (AAAI) Fall Symposium on Applications of Artificial Intelligence for Instantiating Real-World Agents*, Raleigh, North Carolina, October 22-24, 1993, pp. 23-25.

xxxv. Brutzman, Donald P., "From virtual world to reality: designing an autonomous underwater robot," *American Association for Artificial Intelligence (AAAI) Fall Symposium on Applications of Artificial Intelligence to Real-World Autonomous Mobile Robots*, Cambridge, Massachusetts, October 23-25, 1992, pp. 18-22.

xxxvi. Brutzman, Donald P., Compton, Mark A. and Kanayama, Yutaka, "Autonomous Sonar Classification using Expert Systems," *Proceedings of the IEEE Oceanic*

Engineering Society Conference OCEANS 92, Newport, Rhode Island, October 26-29, 1992, pp. 554-559.

xxxvii. Brutzman, Donald P., Kanayama, Yutaka, and Zyda, Michael J., "Integrated Simulation for Rapid Development of Autonomous Underwater Vehicles," *Proceedings of the IEEE Oceanic Engineering Society Conference Autonomous Underwater Vehicles (AUV) 92*, Washington DC, June 2-3, 1992, pp. 3-10.

Invited conference papers

xxxviii. Brutzman, Donald P., Eugene Chan, Mark Evans, Timothy Holliday, Michael Huck, Robert Jezek, BinBing Ma, Steve Murley, Ronald Toland, Young Yee, "Minefield Search Tactic Evaluation using 4 Autonomous Manta UUVs," *Symposium on Technology and The Mine Problem*, Naval Postgraduate School, Monterey California, April 6-10 1998.

xxxix. Brutzman, Don, Brauns, Bryan, Fleischman, Paul, Lesperance, Tony, Roth, Brian and Young, Forrest, "Evaluation of AUV Search Tactics for Rapid Minefield Traversal using Analytic Simulation and a Virtual World," *Symposium on Technology and the Mine Problem*, Mine Warfare Association, Naval Postgraduate School, Monterey California, November 18-21 1996.

xl. Brutzman, Donald P., Macedonia, Michael R. and Zyda, Michael J., "Internetwork Infrastructure Requirements for Virtual Environments," *White Papers - The Unpredictable Certainty - Information Infrastructure through 2000*, NII 2000 Steering Committee, Computer Science and Telecommunications Board, National Research Council, National Academy Press, Washington DC, 1997. Invitational workshop held May 23-24 1995.

Presentations

xli. Childs, Timothy and Brutzman, Don, *Web3D Roundup*. Two-hour program of live real-time 3D graphics demonstrations. Our jury typically accepts 25 entries out of 60-70 entries. Attendance figures at SIGGRAPH 1999 & 2000 are 1700 & 2200, respectively. AVW Graphics Inc. of Houston Texas provides audio-visual support and characterizes this event as the most technically challenging of all their venues, which include the National Association of Broadcasters (NAB) annual exposition and other premiere entertainment-industry events. Web3D Roundup was presented at SIGGRAPH in New Orleans Louisiana August 2000, Los Angeles California July 1999, Orlando Florida July 1998 and Los Angeles California July 1997. Smaller-audience (300-500 people) Web3D Roundups were also presented at ACM-sponsored VRML/Web3D Symposia held in Monterey California February 2000/1998/1997, and Paderborn Germany February 1999.

xlii. Parisi, Tony, Akthinoglu, Murat and Brutzman, Don, X3D Workshop, held at *Web3D/VRML 1999*, Paderborn Germany. 90 attendees. We described and discussed technical foundations and strategic plans for development of X3D.

xliii. McCann, Mike (MBARI), Paduan, Jennifer (MBARI) and Brutzman, Don (NPS), "Interactive 3d Data Visualization In Monterey Bay," poster session and demonstrations, *Monterey Bay National Marine Sanctuary Symposium*, Seaside California, March 20 1999.

xliv. Brutzman, Don, "Virtual Kelp Forest Model," presentation and demonstration, Monterey Bay Aquarium (MBA) Student Oceanography Club (SOC), Monterey California, October 13 1998.

xlv. Brooks, Rex, Brutzman, Don and Hahner, Linda, "The Educational Uses of VRML: From PreSchool to Higher Education," seminar presentation to School of Education, University of California Berkeley, October 12 1998.

xlvi. Brutzman, Don and class, "Virtual Kelp Forest Model," day-long demonstration, National Ocean Conference, Monterey California, June 12 1998.

xlvii. Brutzman, Don, Pesce, Mark, Bell, Gavin, van Dam, Andy and AbiEzzi, Salim, "VRML: Prelude and Future," *Proceedings Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH 96)*, New Orleans Louisiana, August 4-9 1996.

xlviii. Brutzman, Donald P., "A Virtual World for an Autonomous Underwater Vehicle," *Visual Proceedings, Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH) 94*, Orlando Florida, July 24-29, 1994, pp. 204-205. Documents week-long demonstration of virtual world to SIGGRAPH attendees at Emerging Technology venue "The Edge."

xlix. Rhyne, Theresa Marie, Brett, George, Brutzman, Don, Cox, Donna J. and Santos, Adelino, "Exploiting Networks for Visualization and Collaboration: No Network Roadblocks?," discussion panel, *Association for Computing Machinery (ACM) Special Interest Group on Computer Graphics (SIGGRAPH) 94*, Orlando Florida, July 24-29, 1994, pp. 481-482.

Refereed technical reports

l. Brutzman, Donald P. and Compton, Mark A., "AUV Research at the Naval Postgraduate School," *Sea Technology*, vol. 32 no. 12, December 1991, pp. 35-40.

Non-refereed technical reports

li. Davis, Duane, Brutzman, Don and McGhee, Robert, *Phoenix Autonomous Underwater Vehicle Recovery Software Reference*, technical report NPS-CS-96-008, Naval Postgraduate School, Monterey California, December 1996.

lii. Brutzman, Donald P., *Software Reference: A Virtual World for an Autonomous Underwater Vehicle*, technical report NPS-CS-010-94, Naval Postgraduate School, Monterey California, December 1994.

liii. Badr, Salah M., Byrnes, Ronald B., Brutzman, Donald P. and Nelson, Michael L., *Real-Time Systems*, technical report NPS-CS-92-004, Naval Postgraduate School, Monterey, California, February 1992.

Published computer programs

liv. AUV Underwater Virtual World. The NPS AUV underwater virtual world can comprehensively model all salient functional characteristics of the real world in real time. This virtual world is designed from the perspective of the robot, enabling realistic AUV evaluation and testing in the laboratory. Components include tri-level robot software, hydrodynamics models, sonar models, robots, bathymetric terrain and numerous other components. Originally provided in C++ for SGI workstations, software conversions are nearly complete using Java, VRML and MatLab for platform independence. Available on request.

lv. DIS-Java-VRML. I established and chair the DIS-Java-VRML Working Group, sponsored by the Web3D Consortium. The IEEE Distributed Interactive Simulation (DIS) Protocol is used to communicate state information among multiple entities participating in a shared network environment. Java is a portable networked programming language that can interoperate on any computer that includes a Web browser. The Virtual Reality Modeling Language (VRML) enables platform-independent interactive 3D graphics across the Internet. The DIS-Java-VRML Working Group is developing a free software library, written in Java and interoperable with both DIS and VRML. My role includes testing and quality control of all open-source contributions. Applications include a large-scale georeferenced Capture the Flag game for helicopters, tanks, missiles, humanoids, agents and radio-signal visualizations. Online at http://www.web3D.org/WorkingGroups/vrtp/dis-java-vrml

lvi. Virtual reality transfer protocol (vrtp). vrtp is being developed to provide client, server, multicast streaming & network-monitoring capabilities in support of internetworked 3D graphics and large-scale virtual environments (LSVEs). Essentially, vrtp augments the hypertext transfer protocol (http) to provide the network capabilities needed by LSVEs. Current compatible software components include DIS-Java-VRML, Recursive Ray Acoustics (RRA), and RTP Monitor. The Dynamic Behavior Protocol (DBP) streaming component will be publicly released during first-quarter 2001. Online at http://www.web3d.org/WorkingGroups/vrtp

lvii. Extensible 3D (X3D) Graphics tagset and interfaces. I chair the X3D Task Group of the Web3D Consortium, which is designing and implementing the next-generation Extensible 3D (X3D) Graphics specification. We are expressing the geometry and behavior capabilities of VRML 97 using the Extensible Markup Language (XML). I co-authored the original version of the Document Type Definition (DTD) for the X3D tagset with Rick Goldberg of Sun Microsystems, and also authored extensibility DTDs for GeoVRML, Humanoid Animation and DIS-Java-VRML. Rick Goldberg and I also developed the draft X3D Scene Authoring Interface (SAI), an extensive application-programming interface (API) composing VRML with the XML Document Object Model (DOM). I currently maintain X3D revisions and the associated web pages. Available online at http://www.web3d.org/TaskGroups/x3d

Recently I added 270 X3D examples which were manually translated from VRML to X3D. This is significant because I wrote programs which read the original source examples and autogenerate entire cross-linked Web-page directories automatically documenting the latest updates, a task that would otherwise take hundreds of hours of manual editing. This significantly improves our ability to archive and extend student modeling efforts, among other examples. Available at http://www.web3D.org/TaskGroups/x3d/translation/examples/toc.html and http://www.web3D.org/TaskGroups/x3d/translation/examples/Vrml2.0Sourcebook/ toc.html

lviii. X3D-Edit is a graphics file editor that I have written for Extensible 3D (X3D) that enables simple error-free editing, authoring and validation of X3D or VRML scene-graph files. X3D-Edit uses the XML tagset defined by the X3D DTD in combination with Sun's Java, IBM's Xeena XML editor, and an editor profile configuration file. On behalf of the Web3D Consortium, I successfully negotiated a free license for distribution and use of IBM's Xeena software together with X3D-Edit. Recent additions include tagset extensions for Humanoid Animation (H-Anim), GeoVRML 1.0 and DIS-Java-VRML. Integrating hundreds of tooltips and technical hints for each node and attribute in the VRML/X3D scene graph is an excellent way to succinctly distill years of detailed teaching advice in a context-sensitive way. Each tip is presented as needed by the student or scene author.

Latest X3D-Edit software and example scenes are available online at http://www.web3D.org/TaskGroups/x3d/translation/README.X3D-Edit.html

Video proceedings, jury review

lix. Brutzman, Donald P. and Whitfield, Martin, editors, *Video Proceedings of the IEEE Oceanic Engineering Society (OES) OCEANS 96*, Fort Lauderdale Florida, September 23-26, 1996.

lx. Brutzman, Donald P. and Holden, Michael J., editors, *Video Proceedings of the IEEE Oceanic Engineering Society (OES) Autonomous Underwater Vehicles 1996*, Naval Postgraduate School, Monterey California, June 3-6 1996. Includes video segment by Healey, Tony, Marco, Dave, Brutzman, Don and Davis, Duane, "Phoenix AUV In-Water Tests with Virtual World Design."

lxi. Brutzman, Donald P., editor, *Video Proceedings of the IEEE Oceanic Engineering Society 1994 Autonomous Underwater Vehicle Conference*, Charles Stark Draper Laboratories, Cambridge Massachusetts, July 19-20 1994. Includes two self-produced video segments: "A Virtual World for an Autonomous Underwater Vehicle" and "MBone: Multicast Backbone Audio/Video Tools for International Collaboration."

lxii. Brutzman, Donald P., editor, *Video Proceedings of the Eighth International Symposium on Unmanned Untethered Submersible Technology*, University of New Hampshire, Durham New Hampshire, September 27-29 1993.

lxiii. Brutzman, Donald P., Floyd, Charles A. and Whalen, Russell, "Naval Postgraduate School Autonomous Underwater Vehicle," *Video Proceedings of the IEEE International Conference on Robotics and Automation 1992*, Nice, France, May 1992.

Compact disks (CDs)

lxiv. Thesis appendices for David Laflam and Thomas Miller, September 2000.

lxv. Brutzman, Don, Jepson, Anders, Laflam, David and Polys, Nick, *Extensible 3D (X3D) Graphics Software Development Kit (SDK) Summer Edition*, July 2000. Thirty contributions comprising 700MB of software tools, open-source software code, applications and exemplar content for developing X3D tools and applications. Includes DIS-Java-VRML, vrtp and X3D-Edit distributions. 3500 copies distributed. Review oversight by Web3D Board of Directors. Available at http://sdk.web3D.org

lxvi. Glidden, Rob and Brutzman, Don, *Extensible 3D (X3D) Graphics Software Development Kit (SDK)*, February 2000. 500 copies distributed. Review oversight by Web3D Board of Directors. Available at http://sdk.web3D.org

3. External Professional and Service Activities (Indicate membership, leadership role, nature of service and accomplishment.)

   a. Navy/DoD Activity. List any contributions to the mission of the Navy and Marine Corps, or to other DOD activities, including consulting, workshops, and advisory boards, or temporary assignments to operational units, systems commands, laboratories or headquarters.

      i. Fleet Battle Experiment Hotel (FBE-H). Shore-side participant in AUV search, classification and data collection efforts, August 2000.
      ii. SSN 21. Ship visit to examine combat control system, July 2000.
      iii. Naval Undersea Warfare Center (NUWC). Ongoing laboratory visits (1996-present) regarding visualization of tactical environments, combat control systems, design and software development of tactical decision aids, multicast networking, autonomous underwater vehicles, etc.
      iv. Commander, Submarine Development Squadron TWELVE. Drafted and executed NPS-DEVRON Memorandum of Understanding to establish a regular an ongoing technical exchange, supporting both NPS students and emerging fleet requirements.
      v. NAVSEA Advanced Science and Technology Office (ASTO). Ongoing visits as a member of Operational Integration Working Group, evaluating systems and making recommendations regarding user interfaces and tactical decision aids.

   b. External Professional Activities. Professional societies, industrial or academic consulting, workshops/conferences/sessions organized (including dates, place, faculty member's role), paper discussant, seminars, etc.

      Professional societies

      i. IEEE. Member, Institute of Electrical and Electronic Engineers. Active participant or subscriber in oceanic engineering, graphics, visualization, robotics and networking societies.
      ii. ACM. Member, Association of Communication Machinery. Active participant or subscriber to Special Interest Groups on graphics (SIGGRAPH), communications (SIGCOMM), artificial intelligence (SIGART).
      iii. AAAI. Member, American Association of Artificial Intelligence.
      iv. MTS. Member, Marine Technology Society.

      Industrial and academic consulting

      v. I2Soft/Nexternet. Topics related to large-scale internetworked 3D graphics. San Jose California, 2000.

vi. Fraunhofer Center for Research in Computer Graphics (CRCG). Wide-area network (WAN) connectivity, internetworked 3D graphics research and development. Providence Rhode Island, 1999.

vii. UB Networks. Market analysis for 3D browser capabilities and opportunities. San Jose California, 1997.

Workshops/conferences/sessions organized

viii. SIGGRAPH 2001. Online chair. Responsible for digital recording, archive and Web access of all papers, all panels and 5 courses (approximately 120 sessions). A project of such scope has not been previously attempted. Committee meetings held every 8 weeks over a 2-year period, SIGGRAPH 2001 will take place July 2001 in Los Angeles California. http://www.siggraph.org/s2001/cfp

ix. Web3D/VRML 2000. General chair, program committee member. Premiere academic small conference on Web-based 3D graphics. Includes peer-reviewed papers, panels and exhibits. Monterey California, February 2000.

x. Virtual Reality Science and Technology (VRST) 1999. Program committee member.

xi. Web3D/VRML 1999. Program committee member. Premiere academic small conference on Web-based 3D graphics. Includes peer-reviewed papers, panels and exhibits. Paderborn Germany, February 1999.

xii. NCUW. Program committee member and group leader during Network-Centric Undersea Warfare workshop at NPS 8-10 July 1998.

xiii. Mine Warfare Symposium 1998. Program committee member.

xiv. ONR Shallow-Water AUV Modeling & Simulation Workshop. Participant, January 98

xv. Web3D/VRML 1998. Technical program chair and local arrangements chair. Premiere academic small conference on Web-based 3D graphics. Includes peer-reviewed papers, panels and exhibits. Monterey California, February 1998.

xvi. VRML 97. General chair and local arrangements chair, reestablished conference after 2-year hiatus. Premiere academic small conference on Web-based 3D graphics. Includes peer-reviewed papers, panels and exhibits. Monterey California, February 1997.

xvii. Mine Warfare Symposium 1996. Program committee member.

xviii. AUV 96. Technical program chair. Provided first live networking to an NPS-hosted conference at the Hyatt Regency hotel through use of our directional wireless bridges from NPS Spanagel Hall.

c. Other external service activities including, e.g., community service.

i. Web3D Consortium. Founding member, Technology vice president, technical activities board, board of directors. Chair of DIS-Java-VRML, vrtp and X3D working groups. Responsibilities included intellectual property rights (IPR) policy review and establishment of multiple open-source software code bases. Perform in-depth technical review on Web3D draft Recommended Practices and International Standards Organization (ISO) draft standards.

ii. World Wide Web Consortium (W3C). I serve as Web3D's representative to the W3C Advisory Committee (AC). This group meets twice yearly to review and advise on all manner of Web-based standards and protocols under development. Only one representative from each of the ~400 members is allowed to participate in AC activities. In this role, Web3D has made several key recommendations that are resulting in improved interoperability between 3D graphics and better-known Web-based media such as XHTML web pages, audio, video and Scalable Vector Graphics (SVG).

iii. Access Monterey Peninsula (AMP). During 1998-2000 I helped establish a new public-access cable TV station for City of Monterey. Our business model allows potential partnership among seven regional cities. I served as founding member and first chair of the AMP Board of Directors.

iv. I3LA/ ATM. Founding participant and member of regional partnership for high-speed communications which helped establish regional Internet connectivity for K-12 schools with institutions of higher learning.

v. S.E.A. Lab Monterey Bay: Science Education Adventure. S.E.A. Lab Monterey Bay is working to establish a unique residential educational experience for children, their families and teachers: one that fosters a life-long sense of excitement, scientific understanding and respect for our oceans and inspires stewards today for the oceans of tomorrow. The Monterey Bay region is home to the nation's largest marine protected area, the Monterey Bay National Marine Sanctuary. S.E.A. Lab Monterey Bay will use the sanctuary as a focal point of scientific discovery and for learning about our nation's ocean management and conservation programs. I serve on the Board of Directors with special responsibility for website and facilities. S.E.A. Lab completed a successful pilot program in August 2000 and is now raising funds for a capital campaign to establish a long-term residential site. I am working with the NPS Foundation, Oceanography Department and Public Works Officer to prepare construction plans for refurbishing and converting unused Navy property on

Del Monte Beach as a classroom and wet laboratory for S.E.A. Lab students. http://www.SeaLabMontereyBay.org